

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
14 November 2002 (14.11.2002)

PCT

(10) International Publication Number
WO 02/091078 A1

(51) International Patent Classification⁷: **G03B 27/68, 27/42**

[US/US]; 3 Wallace Street, Somerville, MA 02144 (US).
ROTHSCHILD, Mordechai [US/US]; 46 Alderwood Road, Newton, MA 02159 (US).

(21) International Application Number: **PCT/US02/14523**

(22) International Filing Date: **7 May 2002 (07.05.2002)**

(25) Filing Language: **English**

(26) Publication Language: **English**

(30) Priority Data:
60/289,217 **7 May 2001 (07.05.2001)** US

(71) Applicant (*for all designated States except US*): **MASSACHUSETTS INSTITUTE OF TECHNOLOGY** [US/US]; 77 Massachusetts Avenue, Cambridge, MA 02139 (US).

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): **SWITKES, Michael**

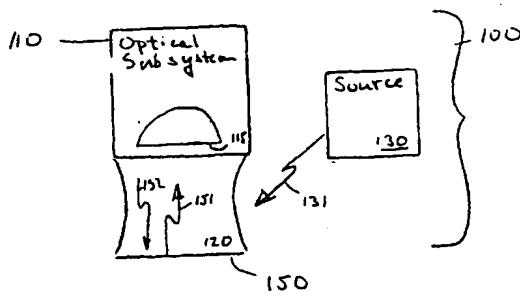
(74) Agent: **POWERS, Jeffrey, B.; Wolf, Greenfield & Sacks, P.C., 600 Atlantic Avenue, Boston, MA 02210 (US).**

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR,

[Continued on next page]

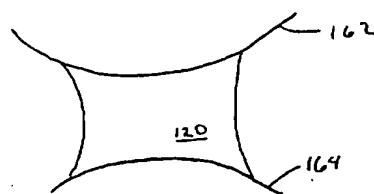
(54) Title: METHODS AND APPARATUS EMPLOYING AN INDEX MATCHING MEDIUM



(57) Abstract: A perfluoropolyether (PFPE) index matching medium (120). The medium (120) may be used with electromagnetic radiation (152) having a wavelength below 220nm. The medium (120) may be used between two optical surfaces (115 and 150) or between an optical surface (115) and an object (150). The medium (120) may be used as an immersion fluid in an immersion lithographic system (100).

A

160



B

WO 02/091078 A1

WO 02/091078 A1



GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent
(BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR,
NE, SN, TD, TG).

— *with amended claims*

Date of publication of the amended claims: 3 April 2003

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Published:

— *with international search report*

AMENDED CLAIMS

[received by the International Bureau on 2 December 2002 (02.12.02);
original claims 1-16 replaced by amended claims 1-16 (2 pages)]

1. An optical system for transmitting light, comprising:
 - an optical surface; and
 - a liquid PFPE medium contacting at least a portion of the optical surface, the liquid PFPE medium configured to transmit at least a portion of the light.
2. The optical system of claim 1, further comprising a second optical surface, the liquid PFPE medium contacting at least a portion of the second optical surface.
3. The optical system of claim 1, wherein the optical system is a collection optical system.
4. The optical system of claim 1, wherein the optical system is a projection optical system.
5. An immersion lithographic system for projecting electromagnetic radiation onto a resist covering at least a portion of a substrate, comprising:
 - an electromagnetic radiation source providing light having a wavelength less than 220 nanometers;
 - an optical surface; and
 - an index matching medium contacting the optical surface and configured and arranged to contact the resist, the optical surface and index matching medium configured and arranged to transmit at least a portion of the light to the resist.
6. The immersion lithographic system of claim 5, wherein the index matching medium is characterized by a transmission of the light, and the transmission remains substantially constant during an exposure of the resist.
7. The immersion lithographic system of claim 5, wherein the medium is substantially transparent to the light.

8. The immersion lithographic system of claim 5, wherein the medium is substantially transparent after a dose of approximately 10 J/cm^2 .
9. The immersion lithographic system of claim 5, wherein the medium is a liquid.
10. The immersion lithographic system of claim 9, wherein the liquid is a PFPE.
11. The immersion lithographic system of claim 10, wherein the liquid is Fomblin Y®.
12. The immersion lithographic system of claim 10, wherein the liquid is Fomblin Z®.
13. A method of transmitting light, comprising an act of:
transmitting light through a liquid PFPE medium.
14. The method of claim 13, wherein the light has a wavelength less than 220 nm.
15. The method of claim 13, further comprising transmitting the light through at least a portion of a first optical surface, wherein the first optical surface is in contact with the liquid PFPE medium.
16. The method of claim 15, further comprising transmitting the light through at least a portion of a second optical surface, wherein the second optical surface is in contact with the liquid PFPE medium.